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H4L
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H04K

(54) **Frequency hopping assignment for radio stations**

(57) A frequency hopping assignment arrangement comprises a processor P in which is stored terrain data, radio performance data and hopper performance data. The processor is provided with a keyboard K whereby geographical input information, information relating to the nets and the assignment requirements are entered. The processor is arranged to execute an algorithm which in association with the stored data and the information input by the input means causes the frequency hopping arrangement to assign the hopping frequencies.

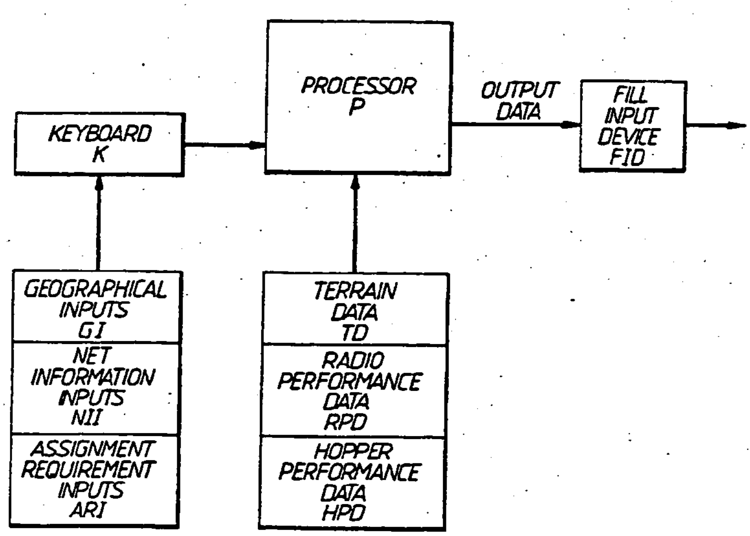

FIG.2.

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The drawing(s) originally filed was (were) informal and the print here reproduced is taken from a later filed formal copy.

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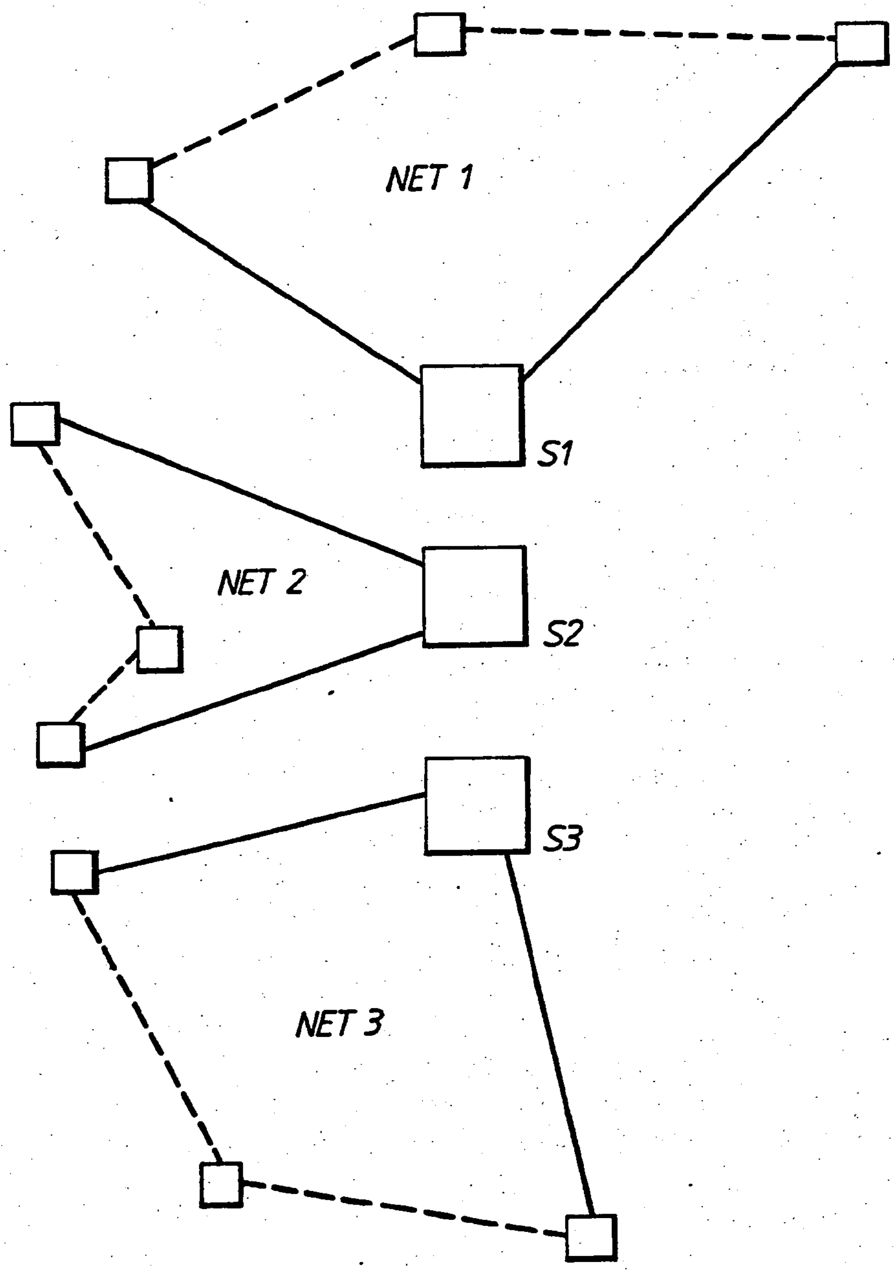

FIG.1.

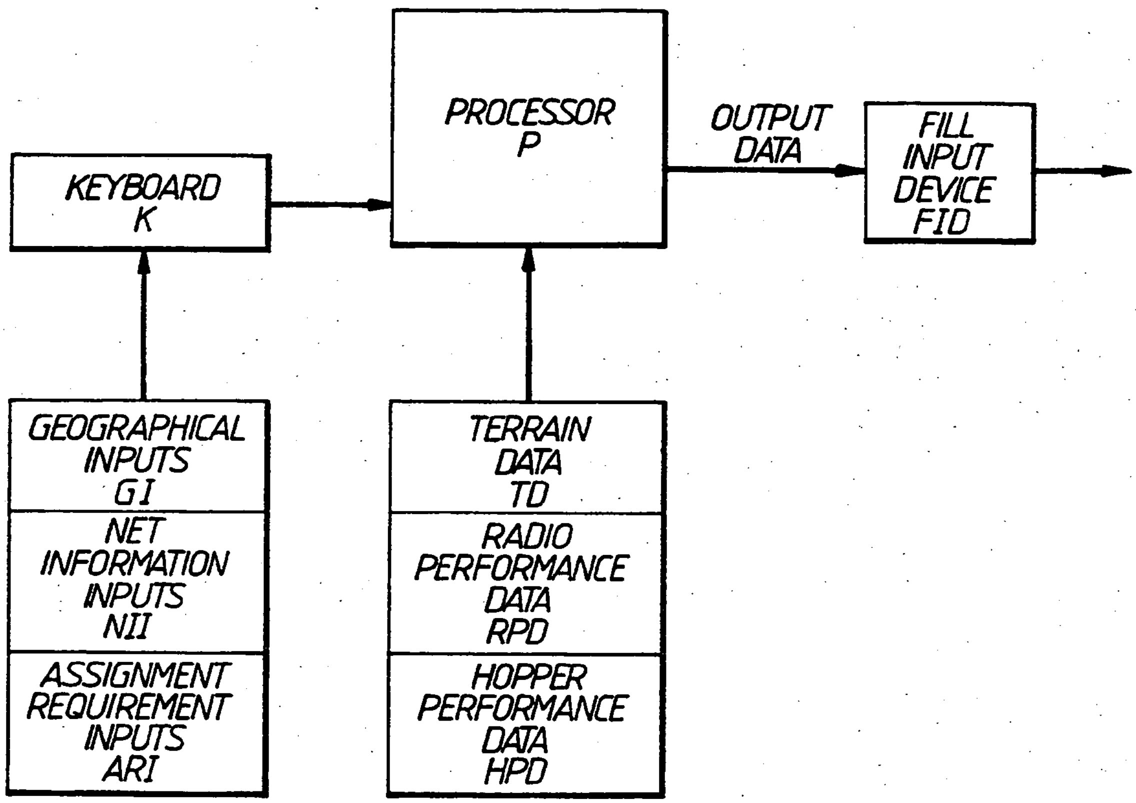
KEYBOARD K
PROCESSOR P
OUTPUT DATA
FILL INPUT DEVICE FID
GEOGRAPHICAL INPUTS GI
NET INFORMATION INPUTS NII
ASSIGNMENT REQUIREMENT INPUTS ARI
TERRAIN DATA TD
RADIO PERFORMANCE DATA RPD
HOPPER PERFORMANCE DATA HPD

FIG. 2.

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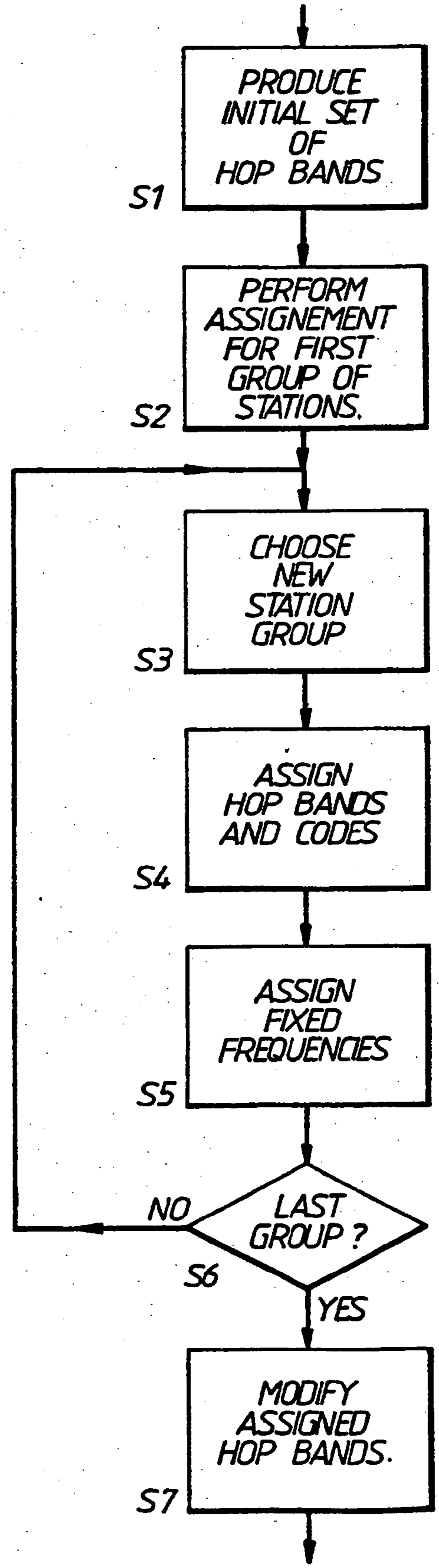

FIG.3.

Frequency Hopping Assignment Arrangement for Frequency Hopping Radio Stations

The present invention relates to a frequency hopping assignment arrangement for frequency hopping radio stations.

A typical example of frequency hopping radio deployment is shown is Figure 1. Three nets S1, S2, and S3 are shown in close proximity to each other. Each net comprises a number of stations S1, S2 and S3 for example. Only the stations in each net communicate with each other, there is no internet communication. The radio equipments S1 to S3 each belong to a different net and are shown close to each other, and unless properly controlled will cause considerable mutual interference. In known systems employing frequency hopping this control is very difficult.

Accordingly an aim of the present invention is to provide a means whereby hopping data may be assigned to each net in such a way that interference among nets is reduced to a level which does not reduce the ability of radio stations to communicate. The invention is applicable when any number of nets are deployed with any proportion of them being hopping nets.

According to the present invention there is provided a frequency hopping assignment arrangement for frequency hopping radio stations, said arrangement comprising processor means in which is stored terrain data, radio performance data and hopper performance data, said processor being provided with input means whereby geographical information, information relating to the nets and the assignment requirements are entered, the processor is

arranged to execute an algorithm which in association with the stored data and the information input by the input means causes the frequency hopping assignment arrangement to assign the hopping frequencies.

An embodiment of the present invention will now be described with reference to the accompany drawings in which:

Figure 1 shows a typical deployment of frequency hopping radio stations,

Figure 2 shows a block diagram of a system used to assign the hopping frequencies; and,

Figure 3 shows a flow chart of an algorithm which is executed by the system shown in Figure 2 to achieve the assignment of the hopping frequencies.

Refering to Figure 2 the system for assigning the hopping frequencies will now be described. The system comprises a processor P having an associated store S in which is stored terrain data TD, radio performance data RPD and hopper performance data HPD. The terrain data relates to the local terrain in which the radio stations are operating so the propagation loss can be calculated and compensated for. The radio performance data is related to the basic parameters of the radio stations which are currently being used. Such parameters relate to the selectivity, sensitivity and power output of the radio stations, for example. The hopper performance data HPD relates to whether full band or narrow band operation is required. The processor is provided with an input device such as a keyboard via which geographical inputs GI, net information inputs NII and assignment requirement inputs ARI are inputted to the

processor P. The geographical inputs GI identify the location of the radio stations. The net information input NII indicates the identity of the net and whether it is a fixed or a hopping frequency net. The assignment requirement inputs ARI indicate whether the net is in use or not. The information inputted via the keyboard K may change from day to day, whereas the information stored in the store S is permanent. The processor executes an algorithm to be described later with reference to Figure 3, which taking into account the data inputted by the keyboard and the information stored in the store S generates output data to a fill input device FID. The fill input device FID is a handheld device which is programmed by the output data generated by the processor P and is then transported to each individual radio station to program it . Alternatively, particular radio stations may be filled directly by the processor P.

The technique allows both hopping and fixed frequency equipments to be assigned with low levels of mutual interference. The main steps in the procedure are:

Choose first location to be assigned

This method begins by choosing as many hop bands as there are hoppers in the first location to be assigned. These hop bands are then used, initially, throughout the communications system, i.e. hoppers in all other locations are assigned to one of these bands. The first location to be assigned should, therefore, be the one with the largest number of hoppers.

If two locations have the same number of hoppers, then the one with the larger number of fixed frequency radio stations should be assigned first.

Select a set of hop bands

When an assignment for any location is complete, it will consist of a number of fixed frequencies and a number of hop bands. Hop bands may contain barred bands to prevent interference between hoppers and fixed frequencies.

To ensure that interference among hoppers is kept to a low level, hop bands should not overlap and one hop band should not be within the limits of any other hop band (i.e. one hop band should not surround another).

Before a set of hop bands can be chosen for the first location, the barred bands must be chosen. The method used in this assignment process, is to choose a larger initial barred band, assign some of the fixed frequencies and then put this larger barred band around the fixed frequencies. The hop bands are then constructed by evenly dividing the unbarred channels into as many bands as there are hoppers in the first location.

The choice of initial barred band width must be such that all fixed frequencies will fit within them with no interference. Equations 1 to 5 as performed in step S1 evaluate the initial barred band width and the number which are to be used. As a guide, the initial barred band width works out at up to twice the true value.

Assign first location

Some of the fixed frequencies will already have been assigned and a number of hop bands produced. Each hop band is now assigned, at random, to a net.

The remainder of the fixed frequency nets are then assigned within the initial barred bands already chosen, ensuring that appropriate co-location separations are observed.

Assign other locations

The remaining locations are assigned in descending order of priority.

Modify Hop bands

Hop bands are modified, where possible, to increase the hopping band width of each one.

Each of these steps will be described in more detail with reference to Figure 3.

Selection of Initial set of Hop Bands Step S1

In order to do this, the following parameters must be used.

N_h, the number of hoppers in the first location.

N_{fmax} the maximum number of fixed frequency radio stations in any location.

B_{imax}, the maximum co-location channel separation within the system to be assigned.

Table 1 shows one example of values of B_i for different transmitter powers and station separations.

The following parameters are now evaluated:

Equation 1: $B_n = INT((a^N fmax + b)(2B_i max + 1))$

a and b are factors which depend on $B_i max$ as shown in Table 2.

Equation 2: $a = .9994877 + .00052254\ B_i max - .00001024\ B_i max^2$

Equation 3: $b = .8010246 - .0010451\ B_i max + .00002048\ B_i max^2$

which gives the values shown in Table 2.

Equation 4: $N_s = B_n DIV\ (2\ Bimax + 1)$

if $N_s < 1$ then $N_s = 1$

Equation 5: $B_{as} = B_n\ DIV\ N_s$

B_{as} is the initial barred band referred to in the above paragraph entitled Select a Set of Hop bands and N_s is the number of fixed frequencies which should be assigned initially.

The first N_s fixed frequencies in the first location are assigned such that they are not closer than (B_{as} DIV 2) channels. Each becomes the centre of a band B_{as} wide which will be barred to hopping. These bands may overlap and if any band extends beyond either of the limits of the VHF band, it is reduced accordingly.

The remainder of the band is divided into N_h equal non-overlapping bands, some of which will contain barred bands.

Station Separation m.	Channel Separation Required at transmitter powers shown		
	5W	0.5W	0.05W
0	200	100	50
50	100	50	25
100	50	20	10
200	20	10	4

TABLE 1 - CHANNEL SEPARATIONS REQUIRED

For example, with two hopping nets and one fixed frequency net, the following results might be obtained.

$Nf_{max} = 1$; $Bi_{max} = 100$ a=0.95 b=0.90

$B_n = 371$; $N_s = 1$; Bas = 371

The fixed frequency, chosen at random is channel number 773.

The hop bands are each (2320 - 371)/2 = 974 channels wide.

One band extends from channel 0 to 1344, the second from 1345 to 2319.

Station Separation (Channels)	a	b
200	0.69	1.41
100	0.95	0.90
50	0.99	0.80
20	1.00	0.80
4	1.00	0.80
2	1.00	0.80
1	1.00	0.80

TABLE 2 - VALUES OF a AND b

Assignment of First group of stations Step S2

Each of the N_h hopping radio stations are assigned, at random, one of the hop bands defined in the previous step. Those fixed frequencies in the first location which were not assigned in the previous step, are now assigned within the barred bands, ensuring that the required co-location separations are observed.

Assign Other Locations Steps S3, S4, S5

The remainder of the locations are now assigned in descending order of priority which is decided according to the number of hopping radio stations within a location. A new station group is chosen (S3). A hop band is assigned at random to each hopper within the location ensuring that the same band is used only once. (S4)

Fixed frequencies are then assigned within the barred bands, or within unused hopping bands where this is possible. (S5)

At the end of this step, all hopping radio stations have had bands assigned to them. Step S6 determines if it is the last group. If not, then steps S3-S5 are repeated. If it is the last group, step S7 is performed.

Modify Hop Bands Step S7

Hop bands are now increased in width, and barred bands reduced in width where possible in order to maximise the hopping band widths.

A hopping assignment arrangement has been described in which interference among hoppers is kept to a level which is low enough not to hamper communication, and interference with fixed frequencies is substantially zero.

CLAIMS

1. A frequency hopping assignment arrangement for frequency hopping radio stations arranged in nets, said arrangement comprising processing means including a store in which is stored terrain data, radio performance data and hopper performance data, said processor being provided with input means whereby geographical information, information relating to the nets and frequency assignment requirements are entered, the processor is arranged to execute an algorithm which in association with the stored data and the information inputted by the input means causes the frequency hopping assignment arrangement to assign the hopping frequencies.

2. A frequency hopping assignment arrangement as claimed in claim 1, wherein the processing means in executing the algorithm produces an initial number of hop frequency bands, fixed frequency bands and barred frequency bands for a first location to be assigned and then assigns the bands to stations in the location.

3. A frequency hopping assignment arrangement as claimed in claim 2 wherein the remaining locations are assigned hop frequency bands and fixed frequency bands within barred frequency bands in accordance with the number of hopping radio stations within a location.

4. A frequency hopping assignment arrangement as claimed in claim 3 wherein the processing means determines when the last location is assigned and then modifies the bands by increasing the width of hop frequency bands and decreasing the width of barred bands.

5. A frequency hopping assignment arrangement as claimed in claim 4, wherein information relating to the modified bands is formatted in a fill input device for subsequently programming radio stations at the various locations.

6. A frequency hopping assignment arrangement as claimed in claim 4, wherein information relating to the modified bands is fed directly by the processing means to particular radio stations.

7. A frequency hopping assignment arrangement substantially as hereinbefore described.

8. A frequency hopping assignment arrangement substantially as hereinbefore described with reference to Figures 1, 2 and 3 of the accompanying drawings.

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